A DRAFT MANAGEMENT PLAN FOR THE MOONWORTS *BOTRYCHIUM ASCENDENS, B. CRENULATUM, B. PARADOXUM, & B. PEDUNCULOSUM* IN THE WALLOWA-WHITMAN, UMATILLA & OCHOCO NATIONAL FORESTS

JUNE 1994

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1. Summary

More than 1 month of field work was done in 1993, divided between the North Fork John Day Ranger District of the Umatilla National Forest, the Big Summit Ranger District of the Ochoco National Forest, and in the Eagle Cap Ranger District of the Wallowa-Whitman National Forest. This was combined with ca. three months of field work in 1991 and 1992 (Zika 1992a, 1992b). It resulted in visits by the writer to all known Oregon sites for

Botrychium ascendens (9 sites, 2 population areas)
Botrychium paradoxum (4 sites, 2 population areas)
Botrychium pedunculosum (5 sites, 1 population area)

The majority of known populations of *Botrychium crenulatum* (5 sites, 3 population areas) were visited. Two additional small populations with poor documentation were not seen.

Ca. 75 total sites for other rare *Botrychium* species were documented by the writer. No rare *Botrychium* were found on the Ochoco National Forest. The Desolation Meadow site in the Umatilla National Forest will require some management and monitoring. The large populations of rare ferns in the Lostine River valley and the canyon of Hurricane Cr. will require the most attention. New populations of *Botrychium ascendens* were found at up to 6500 feet in elevation along the Hurricane Cr. Trail.

The recent publication of *Botrychium lineare* (Wagner & Wagner 1994) added a new fern to the Oregon flora. It should be placed on ONHP List 1, threatened or endangered over its entire range (sensu ONHP 1993).

Management must focus on several factors.

The need for additional inventory

Reducing threats to existing populations, such as suppression of natural fires, trampling, grazing, firewood cutting, camping, off road vehicle use and plant succession

Establishing genetic reserves for significant populations of each of the federal candidates

Simple monitoring of populations in reserves and in human disturbed areas over the next ten years

Monitoring of human use in critical areas, to determine a human "carrying capacity" (i.e., recreational use impacts, conflicts and limits), especially in the Lostine River valley, where a comprehensive botanical and recreation management plan is essential.

2. Introduction

In 1993 the Wallowa-Whitman National Forest contracted the Oregon Natural Heritage Program to produce a management plan for all moonworts (*Botrychium* spp.). Cooperating forests were the Umatilla National Forest, and Ochoco National Forest. This immense undertaking was not possible with the limited amount of funds available, as there are 15 named moonwort species in Oregon (Table 1), and 14 of them occur in the Wallowa-Whitman National Forest. Although members of the genus *Botrychium* sometimes grow together, of course each taxon has a unique range, habitat, biology and need for management, as is the case with members of other large Oregon genera (e.g., *Lomatium, Erigeron, Salix, Carex, Juncus* etc.).

The writer discussed the scope of this project with the lead botanist on the Wallowa-Whitman Forest, Paula Brooks. We agreed the draft planning document should focus on:

> New inventory results on each of the forests. The majority of the field work focussed on visiting known critical populations, to gather data for management recommendations.

We selected the species covered using these criteria:

> Providing general guidelines for the management of eight rare *Botrychium* spp. (Table 1) in the Blue Mountain biogeographic province, where the ferns occur in meadow or marsh associations.
>
> Due to limited funds, concentrating on management guidelines for the four east-side species that are candidates for the federal endangered species list (Table 2):
>
> > *Botrychium ascendens*
> > *Botrychium crenulatum*
> > *Botrychium paradoxum*
> > *Botrychium pedunculosum*
> >
> > As a group these four are the rarest of Oregon's moonworts, the ones that face the most immediate threats, and the ones with the largest federal mandate for management, based on existing laws, regulations and ownership patterns.

Taxonomy

The identification and classification of *Botrychium* ferns has been undergoing a revolution over the last two decades. The result has been the description of a number of new taxa endemic to North America (e.g., Wagner and Wagner 1981, 1983c, 1986, 1994; Farrar and Johnson-Groh 1991). In the last five years the advances in our knowledge have come so rapidly that they resemble the computer chip industry. Each year's product is obsolete before its first birthday. At last count there were 15 published species from our state (Table 1), including one state endemic (*B. pumicola*) and three with a type locality in the Wallowa Mountains (*B. ascendens, B. lineare, B. pedunculosum*). One (or more) undescribed species may be named soon from Oregon material (E. Alverson pers. comm.; D. Wagner, 1992, pers. comm.). The recently appreciated speciation of this group is centered in western North America. The Wallowa Mountains are a globally important concentration of *Botrychium* species (Zika 1992a, W. H. Wagner, pers. comm.). Apparently the post-glacial habitats of the Blue Mountain region, especially the Wallowa Mts., have been important as a habitat for many of the taxa, and perhaps played a role in their evolutionary diversification.

David Wagner (1991, 1992) has written a guide to the identification of the moonworts discussed in this report, and the reader is referred to his keys and illustrations. For the uninitiated, the easiest way to study the species is visit populations in the field, and to carefully compare leaf outlines with silhouette photocopies. The graphics in Figure 1 provide a brief summary of the identification features of the four federal candidate moonworts in Oregon. Their identification is subtle, and requires considerable care, especially in the case of *Botrychium crenulatum*.

There are a number of reasons why *Botrychium* species are difficult to identify (Cody and Britton 1989):

1) Herbarium materials, the usual avenue for study, are frequently misidentified, poorly prepared and lack an adequate sample size
2) Each population has numerous juvenile forms with underdeveloped fronds, fertile but nonetheless not easily named
3) Even mature plants are small and simple, thus there are few characters available for defining and recognizing the species
4) They tend to grow in mixed species colonies, like orchids, as reported by Wagner & Wagner (1983a)
5) Most of the species are disjunct and rare in islands of habitat
6) Variations in leaf shapes of each taxon are still imperfectly understood, within and between populations, and between years (Graham and Wagner 1991)
7) Most species are dwarfs, and difficult to find and study
8) Transplanting is usually fatal (Cody and Britton 1989)
9) Technology for growing many *Botrychium* from spores is years (decades?) from perfection (Whittier 1991)

10) Small morphological differences can be perpetuated in populations by the self-fertilizing nature of the gametophytes.

At present pteridologists agree that the four taxa covered here are distinct species (Alverson 1993). Most recent treatments (Lellinger 1985, Morin 1993, Hickman 1993, Kartesz 1994a,1994b) accept all of these species, supporting the prodigious work of Warren and Florence Wagner. Arthur Cronquist (deceased) disagreed with the taxonomic concepts of the Wagners. Cronquist (pers. comm.) had little field experience with the western taxa, and apparently based his taxonomic judgements on shared characters (Gleason & Cronquist 1991, Cronquist et al. 1972, Hitchcock & Cronquist 1973). He lumped a number of *Botrychium* species. This was in sharp contrast to the research and descriptions of the Wagners of Michigan, who emphasized differences rather than similarities in closely related taxa. In general the writer has found the concepts of Herb and Florence Wagner sustainable after study in the field with living plants.

The federal candidate taxa were described in the following articles:

Botrychium ascendens Wagner & Wagner (1986)
Botrychium crenulatum Wagner & Wagner (1981)
Botrychium paradoxum Wagner & Wagner (1981)
Botrychium pedunculosum Wagner & Wagner (1986).

A synopsis of the identification of these plants is provided below.

Identification notes

Botrychium ascendens

Accurate identification of *Botrychium ascendens* is subtle, and requires some field experience and study of verified specimens (or photocopies). Silhouettes of plants from the type locality are provided in Figure 1. It is closest to *B. minganense* and *B. crenulatum*, but depauperate specimens of *B. simplex* are often mistaken for it. The keys in D. Wagner (1991) provide distinctions between the species. Living plants are green, not gray-green, and have erect blades. The upper segments are strongly ascending, serving to distinguish it from *B. crenulatum* and *B. minganense*. *Botrychium campestre* is similar, but has spherical gemmae on its roots and oddly coalesced pinnae, and an especially wide rachis on the sporophore and trophophore. *B. lineare* has much more slender and straight-sided segments. Suggested citations for further notes on field and herbarium recognition of *Botrychium ascendens* are Wagner and Wagner (1983b, 1986, 1990a), Wagner and Devine (1989), Lorain (1990), D. Wagner (1991). Illustrations besides Figure 1 include: Wagner and Wagner (1983b, 1986), Lellinger (1985), Wagner and Devine (1989), Lorain (1990), D. Wagner (1990, 1991).

Botrychium crenulatum

The difficulties of identification are compounded due to the similarity of its juvenile plants to forms of *B. simplex, B. minganense* and *B. lunaria.* Mature plants (Figure 1) are somewhat more frail than *B. lunaria*, are thinner (less fleshy) and exhibit more veins in the leaf blade. Mature *Botrychium lunaria* pinnae are numerous, broad and hence overlapping, while *Botrychium crenulatum* pinnae are fewer in number, less fan-shaped, better separated and hence not overlapping. *B. crenulatum* leaflets are broader that those of *B. minganense.* W. Wagner (pers. comm.) points out that the well-developed secondary branches (like a tiny Christmas tree) on the sporophores of *B. crenulatum* are often helpful in identifying specimens, even small ones. *B. simplex* blades are blunt apically, and do not possess the narrow, well-spaced sparse terminal segments that the fronds of *B. crenulatum* display. *Botrychium crenulatum* is a bright green, non-glaucous plant, and favors a wetter habitat than all other Oregon species except *B. multifidum, B. simplex* and *B. virginianum.* Like these other three, it can be found in slightly more mesic habitats. There are references with keys and copious illustrations: Wagner and Wagner (1981, 1986, 1990a), Wagner and Devine (1989), Lorain (1990), D. Wagner (1991).

Botrychium paradoxum

Botrychium paradoxum is unique with twin sporophores and no trophophore (Figure 1). However, rare shaded specimens of *Botrychium minganense* (cover illustr.) or *B. montanum* may simulate *B. paradoxum.* The third remains distinctive in its gray-green color, equal and erect primary branches, and generally suppressed secondary branching. Occasional plants of *Botrychium pedunculosum* are "skeletonized" and have virtually no lamina on a trophophore that is entirely converted to sporangia. However, such *Botrychium pedunculosum* have a highly branched trophophore remnant, and these plants are distinct in their red midvein and red stripe down the common stalk, while *Botrychium paradoxum* has a glaucous gray-green, not red, midvein and common stalk. More illustrations, keys, and descriptions can be found in: Wagner and Wagner (1981), W. Wagner et al. (1984), Lorain (1990), Wagner and Wagner (1983b, 1986).

Note that all species of *Botrychium*, even members of other subgenera such as *B. virginianum*, can bear marginal sporangia on the expanded photosynthetic "sterile" axis (blade), and thus there are many false reports of *B. paradoxum.* Some of the species commonly showing marginal sporangia on the trophophore are *B. ascendens, B. pedunculosum* and *B. minganense.* During this survey the condition (supernumerary sporangia) was also observed, but rarely, on *B. crenulatum, B. lanceolatum, B. montanum, B. multifidum*, and *B. pinnatum.* A careful examination of even the most extreme examples of fertile trophophores reveals the broadened lamina, which distinguishes them immediately from *Botrychium paradoxum.*

Botrychium pedunculosum

Botrychium pedunculosum is rather easily recognized if one has the luxury of becoming familiar with the plant at the type locality. It is a distinctive member of the genus. It combines several trends: a glaucous gray-green color, reddish striped common stalk and blade midvein (undersurface), frequent marginal sporangia on the blade, an ample sporophore, generally with three main axes, and stubby, angular segments that commonly overlap (Figure 1). It is sometimes confused with *B. pinnatum*, which has a reddish brown base to its common stalk, but a sessile blade, and a green, not gray-green frond. The red-brown pigment can also occur on some individuals of *B. virginianum* and *B. lanceolatum*. As with *B. pinnatum*, these species all differ from *B. pedunculosum* because the red coloration does not extend all the way up the common stalk and along the undersurface of the midvein of the blade.

At least two plants of *B. pedunculosum* from the Lostine Valley showed extreme reduction of the trophophore, where the lamina was largely replaced by sporangia, suggesting the hybrid between *B. hesperium* and *B. paradoxum* called *B. X watertonense* (Wagner et al. 1984). These plants are among a large population of otherwise normal *B. pedunculosum* at the type locality. In the absence of one of the parents of the hybrid, it seems certain that these plants are merely extreme examples of the species' tendency to bear marginal sporangia on the blade. No collections were made of these unusual plants, and they are believed to be "skeletonized" *Botrychium pedunculosum*. More literature on the identification of *Botrychium pedunculosum* can be found in: Wagner and Wagner (1983c, 1986), Lellinger (1985), D. Wagner (1990, 1991), Lorain (1990).

For additional illustrations of *Botrychium pedunculosum* see Wagner and Wagner (1983b, 1986), Lellinger (1985), D. Wagner (1990, 1991).

3. Biology

The gametophyte phase of a fern is illustrated in Figure 2 (Foster & Gifford 1974, Whittier 1991). Figure 3 (Taylor 1984) provides a stylized diagram of the life cycle of a fern, showing the gametophyte (haploid) generation alternating with the sporophyte (diploid) generation. Gametophytes are rarely seen, since they are tiny and grow underground. The sporophyte phase is the familiar green "fern" seen afield. Figure 4 (Lorain 1990) diagrams the terminology used for most *Botrychium* frond structures. Photographs and explanatory terms relating to *Botrychium* topography can be found in Lorain (1990) and D. Wagner (1991).

Gametophyte biology is little known. Several factors appear to be important in this phase of the life cycle for the genus. Spore germination requires darkness, moisture, and unless grown in culture, a carbohydrate source from a mycorrhizal fungus (Whittier 1991). The gametophytes are closely associated with (or perhaps partially parasitic on) mycorrhiza, and are found underground. Wagner et al. (1985) suggested this is an adaptation to habitats such as fields, grassy meadows and other seasonally dry habitats. The gametophytes self-fertilize themselves, perpetuating local ecotypes and facilitating long distance colonization by a single spore. Spores dispersal may be by the wind, or perhaps by grazing animals that consume the sporangia (Wagner et al. 1985). The phenomenon of mammalian dispersal of ferns is poorly understood and needs study, although such studies would be complicated, time consuming and expensive.

Hybrid *Botrychium* plants are the result of gamete movement between the underground gametophytes, facilitated presumably by the motion of water. Hybrids are rarely seen in nature, but there are several records of hybrids in the literature (W. Wagner 1991, Wagner and Wagner 1988). A single hybrid plant of *B. ascendens X crenulatum* was found at the type locality for *B. ascendens* (Wagner and Wagner 1986). W. Wagner collected a hybrid between *B. pedunculosum* and *B. pinnatum* from the type locality of *Botrychium pedunculosum* on the Lostine River (Wagner and Wagner 1986).

There has been considerable discussion and little research on the biology of the genus *Botrychium*. Some of the questions that need investigation are given below, with suggestions for monitoring strategies (and budgeting estimates for the time that might be involved). Most of these studies could take place anywhere in the American west, where there are suitably large, undisturbed populations. The results could be easily applied to the National Forest management plans in Oregon:

> Conservation of plants is based on protection of populations. What is a population? The minute size of a fern propagule (the spore) changes the population definition. Populations of *Botrychium* are fundamentally different from those of the average wildflower, since even widely separated individuals can be connected genetically by wind dispersal of spores. Classic studies have shown that all propagules, regardless of size, are mostly found near the parent in a leptokurtic distribution. But long distance dispersal is much more frequent with ferns than it is with wildflowers. Plants like *Botrychium lunaria* and *Dryopteris filix-mas* are circumpolar colonists, with widely disjunct populations on islands and scattered across the northern continents. Yet even closely spaced gametophytes may never cross-fertilize. Definition of a population is difficult, but is probably most accurately defined with a long-term view: by a watershed rather than by the size of a meadow or woodland. Patches of ferns in different meadows or forested zones within a drainage or sub-drainage are probably very closely related and part of one population. This of course can be tested with any number of modern techniques in the lab, but such testing is time consuming, elaborate and hence expensive. Chloroplast DNA testing, enzyme comparison with electrophoresis, or even old-fashioned chromatography might resolve

population boundaries. A more practical approach is to use watershed lines in defining functional populations, and managing to protect the maximum amount of habitat available within the watershed. This should be applied to the four federal candidate species of *Botrychium* in the Wallowa Mts., the main subject of this report. Such an approach is the only one that is likely to ensure the long-term goal of this management plan: the continued viability of these species over the coming centuries. For other, more widespread species with vast continental or multi-continental distributions, such an approach is not warranted (i.e., *Botrychium lanceolatum, B. lunaria, B. minganense, B. multifidum, B. pinnatum, B. simplex, and B. virginianum*). For such abundant and well-dispersed species, protection of the two largest sites on a National Forest should be pursued, in the traditional manner, rather than attempting to manipulate entire watersheds for their sake.

Species definition in *Botrychium* is a thorny problem that should be submitted to modern analysis, using electrophoresis, etc. There are unpublished studies of some of the North American taxa (W. H. Wagner, pers. comm.; E. Alverson, pers. comm.). This is an area where Forest Service botany programs can contribute the most to the advancement of science, by marking and monitoring populations of taxonomic interest, establishing botanical interest areas, research natural areas, and genetic preserves, and by providing or matching research funds to academics who will study the questions. Until such studies are done there will always be some unanswerable questions about the distinctness of some of the tightly related species complexes in the moonwort sub-genus. These are burning questions, because they affect our long-term management goals, which are focused at the species level.

How is apparent population size affected by normal variation in weather (especially precipitation) from year to year? Marked individuals should be monitored to study this question and demographics (e.g., the techniques and studies of Montgomery 1990, Lesica & Ahlenslager 1994). (Demographic studies would require at least 4 weeks of labor for data collection and analysis/yr.) Another alternative, far less labor intensive, would be simple annual population counts (a census) in small permanently marked plots (ca. one meter squared). Subpopulations in different microsite habitats (e.g., shade vs. sun, mesic vs. xeric) should be sampled. Long-term baseline studies of all 15 of Oregon's *Botrychium* taxa should be established in undisturbed genetic reserves, where simple monitoring data can be compared with data collected in managed populations (an estimated 1.5 weeks of labor/year/species).

Are populations increasing or declining? Does the presence of a few plants on the edge of a meadow represent the first successful colonists, ready to expand and multiply over the next few decades? Or are they the last long-lived random survivors of grazing, or trampling, or a wildfire from 25 years ago, or the only individuals not yet shaded out by the encroaching forest? This is a critical question that must be answered to direct management of a site. Only long-term simple monitoring of population size over the course of at least 5-10 years will answer this question, in

most cases (see sampling described above under population size). It is important to remember that the 15 Oregon taxa will all respond somewhat differently to the same set of environmental parameters, and monitoring studies can not neglect the entire range of species diversity.

How long-lived are individuals? Demographic studies are expensive and time-consuming. But knowledge of the life span, recruitment and reproductive efforts of individual plants is needed in long-term management. It should be addressed for the federal candidates. The simplest way to approach this question would be to mark 100 individuals in permanent undisturbed plots (with a medium density), and note presence or absence over the course of a 10-20 year study (2-3 days/sp/yr). Shorter studies will have the obvious problem of false mortality and recruitment reports if the plants are dormant or damaged for two or three years in a row (as shown by Montgomery 1990). Plots should be placed to minimize trampling and allow for easy access and relocation.

How are *Botrychium* individuals affected by plucking? Botanists "graze" leaves at ground level to make herbarium specimens. David Wagner (pers. comm.) is monitoring the long-term effects of picking leaves of *Botrychium simplex* at a site where it is abundant. Similar studies should be established for all 15 Oregon species, at sites where they are numerous. For the rare Oregon species like *Botrychium paradoxum* and *B. campestre*, this would mean populations out of state would have to be studied. Monitoring of these effects can be done by marking ca. 25 individuals in four permanently marked locations in a population (100 total). Half the plants (50 total) can be picked at ground level after the sporangia have dehisced (and made into herbarium specimens). Return to the 100 plants for at least the next five years and record the number of survivors of plucked and unplucked plants (ca. 3 days data collection and analysis/yr/species). A study shorter than five years would confuse annual climatic variations with treatment results. A ten year study would be more accurate.

How are individuals affected by grazing of leaves? Grazing could occur from slugs, cattle, horses, sheep, deer, elk, rabbits, rodents, etc. Montgomery (1990) found that *Botrychium dissectum*, a close relative of our *B. multifidum*, survived three consecutive years of total defoliation by white-tailed deer; each year it produced one above-ground leaf which was immediately eaten. He suggested that the relationship with endophytic fungi on the roots provided an alternative carbohydrate source, as in some terrestrial Orchidaceae. The orchids *Spiranthes spiralis, Listera ovalis* and *Dactylorchis incarnata* were documented persisting after an entire year underground (Wells 1967, Tamm 1972), where slug predation may have removed the young shoots. Twenty years have elapsed between above ground appearances of another orchid, *Cephalanthera rubra* (Summerhayes 1968), suggesting how vital the fungal carbohydrates can be. A monitoring study of grazing effects can be conducted

similarly to the study of plucking described above. Merely modify the time that the plants are picked, shifting it to earlier in the growing season, before the sporangia are dehisced (time requirements would be the same).

Is mammalian grazing of sporophores important in local spore dispersal (Wagner et al. 1985)? This may be more important in some habitats or for certain species. (Long distance spore dispersal, e.g., between states or continents, is presumably by wind.) Studies would require small mammal trapping in the fern meadows to determine the potential rodent dispersers. Observation of tracks and droppings will add what larger mammals are potential native grazers in the area. An ecological study of the native grazers and their interactions with the fern sporophores would require study by a graduate student, rather than monitoring by the USFS, due to the time and expense involved (ca. 100 work days/yr for several years, at a minimum).

Do the ferns change their apparent morphology from year to year, as they mature? If so, are the species as presently defined sufficiently distinct? Anecdotal accounts from W. H. Wagner and F. Wagner (pers. comm.) strongly discount the possibility that individual plants change from one "species" to another as they mature over the course of several years. Kathy Ahlenslager (pers. comm.; Lesica & Ahlenslager 1994) found individual plants of *Botrychium hesperium, B. paradoxum* and *B. watertonense* were consistent over 3-4 years. Montgomery (1990) did not report any inconsistencies in a 10 year study of *Botrychium dissectum*. The writer has not seen "identity changes" in his six years of observing *Botrychium* in the Wallowa Mts. But more studies are possible to monitor individuals of closely related species like *B. minganense, B. lunaria* and *B. crenulatum*. Permanently marked low density plots with a single species could be easily monitored each year, noting simply the presence or absence of different taxa (2 days/yr/sp for data collection and analysis). Of greater interest would be answering questions about how the leaf morphology changes in response to the amount of shade and moisture at the microsite. Ecotonal transects and habitat manipulations could provide an answer.

Fugitives

Disturbance is an important factor to consider in the habitat management of *Botrychium* species. Many species apparently reproduce in disturbed areas where plants are sparse, such as banks, abandoned roadbeds, well-drained meadows, etc. Biologically this suggests that moonwort gametophytes are sensitive to the density of the surrounding competing roots. Sparse plant communities are often in transition from herbaceous plants to woody plant domination. Ecologically this suggests that *Botrychium* are fugitives from plant succession.

How have *Botrychium* survived over the long-term, in pre-historic times before the introduction of short-term human-caused disturbances like clearcuts, livestock grazing, and road-building? Natural disturbances are abundant in the Blue Mountain province. Stream banks, alluvial fans, glacial till, landslide scars, well-drained clearings with occasional

wildfires, snow avalanches, floodplains, river-ice maintained meadows, and talus margins are examples of naturally disturbed treeless sites in a predominantly forested environment. Presumably *Botrychium* spores found their way from one opening to the next before it reforested. Thus the populations hopscotched around the landscape as fugitives from woody plant succession.

Over the short-term (10-50 years), short-distance dispersal of spores may be sufficient to maintain a population in early successional habitats. As population size builds up the odds of a successful long-term spore dispersal increase.

Mature *Botrychium* (and *Ophioglossum*) sporophytes are sometimes seen in quite dense vegetation, such as thick grasses, dense forbs, or shrub thickets. This suggests that the mature sporophytes can persist for a number of years once established, despite some encroachment from competing plants. These individuals are probably most important to populations as spore sources for long-distance wind dispersal, until they are inevitably crowded out by a heavy growth of woody plants.

The scenario presented above does not account for Cascadian populations of *Botrychium minganense, B. montanum, B. virginianum*, etc. that are found in dense shade under moist old growth forests. They have a fundamentally different ecology, and their spore dispersal may possibly be more closely tied to native rodent grazing and flowing water. Old growth moonworts are fugitives from light. Light in such areas means dense shrub invasion as plant succession starts. Deep shade in intact old growth results in few herbaceous competitors, lots of bare ground, and ample sites for gametophyte establishment. A common long-term problem in old growth stands is leaving an inadequate buffer to prevent windthrow and subsequent shrub invasion around the perimeter of the intact forest. Three tree lengths is a minimum buffer if the watershed boundaries can not be protected.

Human disturbance is not a perfect mimic of natural disturbance. Hence human disturbances such as livestock grazing, road building and clearcutting will not necessarily create or maintain moonwort habitat or mitigate for the loss of moonwort habitat.

> Site maintenance by burning is preferred over grazing to suppress invading woody plants, reduce thatch and create bare ground for fern recruitment. Fire releases nutrients and stimulates graminoids favored as forage by native ungulates. Fire predates cows by thousands of years as a shaping influence on North American vegetation and its succession. Grazing the few *Botrychium* meadows is a minor commercial interest that should be subordinated to maintenance of federal candidate species. Management fires to control woody vegetation do not introduce the long-term baggage that grazing does to the system: trampling, introduction of new exotic invasive competitive or noxious weeds (on fur or in supplemental feed), trampling and eating of immature sporophores that reduces or eliminates *Botrychium* reproduction, reduction of vigor and diminished reproduction of native grassland species, inevitable increases in existing non-palatable species and weeds, degradation of riparian zones

and water quality, increased soil erosion, a decline in fishery values, a change in the meadow fauna, and a need for expensive fencing and fence maintenance. Taken together, these are large risks against the relatively small biological benefits of livestock grazing, which can reduce thatch, stall woody plant encroachment and trample openings that are potential sites for the establishment of *Botrychium* gametophytes. Controlled patchy burns are a preferable, more risk-free long-term management alternative to commercial grazing in *Botrychium* meadows. On the other hand, fire and smoke have some negative short-term effects: lowering air quality, local loss of some nutrients, hot spots that sterilize essential soil fungi, and increased runoff. These can be mitigated by burning at the correct time of the year, such as very early or very late in the growing season, and by burning at 5-15 year intervals, as needed.

Moonworts are sometimes observed on moist or mesic, lightly vegetated, partially stabilized roadbanks. Such sites may be ecological mimics of streambanks and alluvial fans, where *Botrychium* is found in the Wallowa Mts. Over the short-term these populations should be protected from the numerous threats implied by the habitat: invasion of noxious weeds dispersed by vehicles, road shoulder or ditch maintenance, herbicide use, road-widening projects, etc. Intensive vigilance is needed to monitor and ensure the survival of roadside populations, hence building new roads is not suggested as cost-effective or low-risk way to create new habitat or mitigate for the loss of habitat.

Population estimates are reported in Tables 3,5,7,9. It should be noted that during most visits to known populations it was not possible to take a complete census of all individuals. The inventory was designed to find new localities, not census the known ones. This is indicated in Tables 3,5,7,9 by an estimate and the use of a plus sign (+). Thus the estimate represents the number of plants seen that year, but it is not an estimate of the total number of plants in that population. The last two rows of Tables 3,5,7,9 present these data in two ways. The estimated Oregon total of all populations is based on the highest population counts. It sums the highest population counts for all sites (irrespective of the year). CAUTION. The incomplete annual estimates, in the bottom row of the tables, merely gives the number of plants seen that year, and the figures are NOT directly comparable from year to year, since new sites were discovered, and not all old sites were revisited or totally censused.

4. 1993 Survey results

Botrychium ascendens W. Wagner (upward-lobed moonwort)

Range

Figure 5 shows that upward-lobed moonwort is restricted to Wallowa County in Oregon. Beyond our state (Figure 6) it is known from Montana, Nevada (Wagner & Wagner 1983b), California (Wagner and Devine 1989) and from the Canadian provinces of Alberta, British Columbia, Ontario and Yukon Territory (Wagner and Wagner 1986). The species is newly reported from Washington State (WNHP 1994), with a few specimens reportedly verified by one of the three relevant Wagners.

Wagner and Wagner (1986) did not record any other Oregon sites for *Botrychium ascendens* besides the type locality. Small populations of the species have since been found at six other locations on Hurricane Creek (Table 3, Figures 7,8). The second population area includes two small colonies in the Lostine River valley (Table 3, Figures 9-10). These are mapped in detail in the sighting reports of Appendix 1.

Apparently most populations are small, with the exception of the type locality (Figure 7A; Wagner and Wagner 1986) and the meadow north of Billy Jones Creek (Figure 7D).

Wagner and Wagner (1986) reported "hundreds" of plants from their visit in August 1983 to the type locality. A careful count in 1991 yielded 213 individuals (stems). A series of annual population counts are needed to evaluate if the population is declining or stable.

Thirteen *Botrychium ascendens* plants were seen in a xeric meadow ca. 1.5 air miles due south of the Hurricane Creek trailhead (Figure 7C) Four plants were seen in a very small mesic meadow ca. 1.65 air miles south of the Hurricane Creek trailhead (Figure 7B), where they are threatened by camping, fire building, and pack animal grazing and trampling. Circa 50 plants were located by David Wagner in 1988 just north of the confluence of Billy Jones Creek and Hurricane Creek, along the Hurricane Creek trailhead (Figure 7D). The writer and Ed Alverson revisited this site in 1991. It is a wet to mesic meadow series. We counted 91 stems, and noted also a number of other *Botrychium* species. Billy Jones Creek site has good access to water and a pleasant view. These natural attractions and its position at a trail junction invite recreational use such as camping and livestock trampling and grazing, activities which are threats to the population.

The inventory in 1993 discovered a small population of *Botrychium ascendens* in the meadows south of the Billy Jones Cr. confluence (Figure 7E), growing with *Botrychium lunaria*. Until these plants were found, it was thought this area might make a good alternative campground to the *Botrychium ascendens* site north of Billy Jones Cr. This emphasizes the need for careful inventory in all areas where camping and campfires are to be

permitted in the limy basins in or near the Eagle Cap Wilderness.

Two more small populations of *Botrychium ascendens* were found at higher elevations in the Hurricane Cr. drainage, in openings along the Hurricane Cr. Trail (Figure 8). Sixteen plants were found due west of Sacajawea (Table 3, Figure 8A). A solitary *Botrychium ascendens* was seen due west of the Matterhorn (Figure 8B).

W. Herb Wagner took the writer to a small colony of *Botrychium ascendens* in the Lostine Canyon (Figure 9C), where he had first seen it ca. 1983. Two additional plants were observed on private land in 1991 in the Lostine canyon, at the type locality for *Botrychium lineare* (Figure 10A).

Type Locality: The type locality for this recently described species is on Hurricane Creek in the Wallowa Mountains (Wagner and Wagner 1986). The type specimen is *Wagner 83363* and is housed at the herbarium of the University of Michigan, Ann Arbor.

Although Wagner and Wagner (1986) stated the type locality was "ca. 1.5 miles" south of the Hurricane Creek trailhead, the site is more nearly 1.2 air miles due south of the trailhead (see Figure 7), and appears to be at the southern edge of (T3S, R44E) Section 15, not in Section 22 as commonly mapped. Ed Alverson confirmed this is the true type locality; he visited it with Herb and Florence Wagner in August 1983, and with the writer in July, 1991.

The type locality (Figure 7) is on a large alluvial fan composed of limy fragments, in a xeric meadow east of the base of a large gray limestone cliff in the Triassic Martin Bridge formation (Walker 1977, 1979; N. Wagner 1958). The southern end of the meadow, especially near the trail, is more mesic, and is partially shaded by the patchy forest, and this is the favored site of the various moonworts at the site. Some individual plants are found on small banks and slopes incised in the alluvial fan by ephemeral rivulets. Most of the *Botrychium ascendens* are concentrated in two small areas, each less than 150 square meters. One is above the trail, one is below the trail. The site below the trail is reasonably flat and is used for a campground. Here the *Botrychium ascendens* is endangered by indiscriminate camping, trampling and grazing of pack animals, and by campfire building.

Habitat

Botrychium ascendens occurs at elevations of 5250-5970 feet in the Wallowas. All known localities are on Quaternary surficial deposits, generally glacial debris reworked by modern streams. Each locality is on or near sedimentary bedrock in the Hurwal Formation or Martin Bridge Formation, and possibly the ground water is circumneutral or limy. The habitats are mesic meadows along streams or on alluvial fans, and typically have many strawberries (*Fragaria virginiana*). The surrounding forests are predominantly *Picea engelmannii*. Colonies are in full sun, or at the south ends of meadows where they receive some shade from the nearby trees. At the wettest site, Billy Jones Cr., the meadow is marshy, but the

Botrychium ascendens are on dry hummocks or mounds.

Openings in the forested bottoms of the Lostine and Hurricane drainages are curious, presumably temporary phenomena. They are most likely the result of natural processes such as mass movement of the steep hillsides, or paths cleared out by avalanches in exceptional snow years. Because of the altitude, dry summer, thin soil, etc. they are slow to revegetate with trees. These natural openings are surely the original environments of *Botrychium ascendens* in the Wallowas. The species hopscotches between openings as some reforest, and others open. Wildfires may have played an historical role in maintaining, if not opening these meadows.

The grazing history of these meadows is another question that needs to be addressed. High elevation contiguous meadows (*Festuca viridis*, etc. in alpine and subalpine terrain) were overgrazed by introduced summering sheep, resulting in incalculable damage to the vegetation. But some of the patchy small meadows in the forested canyon bottoms may have seen little grazing pressure, where the sheep were not allowed to linger in transit to and from their summer range (C. Johnson, pers. comm.).

Some associates of *Botrychium ascendens* are given in Table 4.

At the type locality Wagner and Wagner (1986) reported *B. ascendens* growing with *B. crenulatum, B. lunaria*, and *B. minganense*. W. Wagner (pers. comm.) also noted finding two individuals of *Botrychium lineare* at the type locality in 1983. The 1991 survey found all of the species reported by Wagner and Wagner (1986), but no individuals of *Botrychium lineare* (Zika 1992a). Four plants of *Botrychium lineare* were seen in 1993, and a voucher was collected by the Wagners and deposited at MICH.

Threats

As discussed above, all the locations in Hurricane Creek (Figures 7,8) are threatened by recreation visitation. The site on private land in the Lostine River basin (Figure 10) is unprotected, and showed evidence of damage by trampling in 1991.

Recommendations: Inventories should precede any management activities in the Lostine, Wallowa, Hurricane and upper Imnaha Rivers. Heavily used recreation areas should be inventoried. Any grazing allotments in the limy portions of these basins should also be inventoried. The type locality and the Billy Jones Cr. population should be designated No camping-no grazing areas, with explanatory signs. A plan for recreation use and limits should be drawn up for the Eagle Cap Wilderness, and it should account for the large number of rare plant species, and the fragility of their habitats. Firewood cutting and camping in the Lostine River should be restricted to areas without botanical values.

More management guidelines are found in the management section of this report.

Botrychium crenulatum W. Wagner (crenulate moonwort)

Range

Besides Oregon, *Botrychium crenulatum* (Figure 11) is known from Montana, Wyoming and all the continental states to the west (Wagner and Devine 1989, Wagner and Wagner 1993). Although it was reported from Alberta (Wagner & Devine 1989) it was not mapped from there in the Flora of North America (Wagner & Wagner 1993).

This species is frequently misidentified. Oregon reports from the Steens Mt. range have proved to be *Botrychium minganense*, not *Botrychium crenulatum* (Zika 1992b). A report from Mt. Ashland in Jackson Co. Oregon (Klamath National Forest, Table 5) was field verified. The county range map is believed to be accurate as of 1993 (Figure 5).

One of the sites given in Table 5 is the type locality for *Botrychium pedunculosum* (Figure 9A). Wagner and Wagner (1986) did not report *B. crenulatum* there, but have confirmed (pers. comm.) the identification of plants collected during this survey (including the specimens used for the illustration in Figure 1).

There are a number of reports of *Botrychium crenulatum* from the Eagle Cap Ranger District in the ONHP database. Until voucher specimens of these can be examined, or the sites relocated, these are assumed to be misidentifications, and are referred to the category of "unidentified *Botrychium*" (see Zika 1992a). Some of these populations were relocated in 1992 or 1993. They were found to be various species, including *Botrychium ascendens*, *B. minganense, B. pinnatum*; in fact, none were verified as *Botrychium crenulatum.*

A Grant County record (Table 5, Figure 12a) was reported in 1992 and consisted of a single individual. The Forest Service Sighting Report is included in Appendix 2. It indicates the plant was found in Section 34 along Howard Creek. A letter from W. H. Wagner, presumably referring to this population, mentions confirming the identification of *Botrychium crenulatum*. This site should be inventoried again, to look for additional individuals. It would be reassuring to have many more well-pressed mature fronds from the site authenticate it, as the habitat described is atypical. If this is truly *Botrychium crenulatum* then more inventory is needed for the species in similar sites in the drainages of Kelsay and Desolation Creeks in the John Day Ranger District of the Umatilla National Forest.

A Forest Service report of *Botrychium crenulatum* from Baker County is mapped in Figure 5 with some doubts. There is no Forest Service location information or documentation for this report, although the writer has seen a photocopy of the collections from there (labeled

"Horse Cr.") and the identity of the plants is likely correct. There are at least five plants on the herbarium sheet, so the population is given as 5+ in Table 5. This site should be reinventoried and documented correctly in 1994.

A final site for Oregon is extralimital. It is on the wet subalpine meadow on the southwest slope of Mt. Ashland, in Jackson County, in the Klamath National Forest. The identity of the tiny population was confirmed in the field by Warren Wagner (F. Lang, pers. comm.) and again by the chief Oregon moonwort skeptic, Peter Zika, in 1993. A sighting report and map is included in Appendix 2. The Klamath National Forest land managers and botanists should be informed of this site, which is an important one despite its small size. It fills in a significant hole in the range of the species between California and northeastern Oregon.

Type Locality: The species was described by Wagner and Wagner (1981) from California.

Habitat

Crenulate moonwort grows at altitudes of 5000 to 6000 feet in the Eagle Cap District. The known populations are on Quaternary surficial deposits or Hurwal Formation sedimentary bedrock. All the sites may be circumneutral or limy. *Botrychium crenulatum* favors mesic to marshy openings, and is tolerant of partial shade but the writer has never seen it in deep shade. In mesic meadows it is found in the wettest or shadiest locations. In California and on Mt. Ashland it is found with *Botrychium simplex*, in marshy mountain meadows. *Botrychium simplex* populations are scattered across all of Oregon's major mountain ranges, but occurrences of *B. crenulatum* remain rare.

Tree species at *B. crenulatum* populations are predominantly *Picea engelmannii* in the Hurricane basin, and *Pinus contorta* along the Lostine River. Some associated species are given in Table 6.

Threats

The *Botrychium crenulatum* population at the *B. ascendens* type locality (Figure 7A) faces the same threats as *B. ascendens*. The population in the Lostine Valley (Figure 9A) at the *Botrychium pedunculosum* type locality is threatened by firewood cutting, campfire building, piling of brush, ORV use, camping, compaction, and the possibility of hydrological changes if the nearby roads are altered. The plants on private land at the Lapover Ranch suffer from trampling (Figure 10A) and the possibility of future development.

Recommendations: Table 5 shows that all known populations of *B. crenulatum* are small. This is significant in the face of the threats to the populations. Priority should be given to

protecting all known Oregon sites. Further inventory is needed in Grant and Baker County, to fill in the details on the populations reported there.

Block off the road access to the *Botrychium pedunculosum* type locality (large boulders would do nicely and have been effective nearby), and revegetate the compacted campground with native grasses (collect seed from the vicinity). Post this area (Figure 9A) as a no camping/no firewood cutting zone. Monitor the moonwort populations. Consider prescribed fire at 7-15 year intervals to maintain the natural openings. Establish the Billy Jones Creek (Figure 7D) and *B. ascendens* type locality (Figure 7A) as no grazing/no camping zones, and use explanatory signs and ranger patrols to back this up. Inventory all meadows on Hurricane Creek and in the headwaters of South Fork Imnaha River for this species.

Additional management recommendations are given in the management section of this report.

Botrychium paradoxum W. Wagner (paradox moonwort)

Range

Botrychium paradoxum is "one of the rarest species in the genus" (Wagner et al. 1984). Currently it is known from four states and three Canadian provinces (Figure 13, Wagner & Wagner 1993, Vanderhorst 1993, WNHP 1994). With a total of only eight individuals known, it is arguably one of the rarest plants in our state. Only in Montana has a large population of this species been recorded (ca. 1000 plants, Vanderhorst pers. comm.).

The discovery of this species in Oregon (by Ed Alverson and the writer) in 1991 added a new fern to the flora of Oregon (Figure 5, Table 7).

One station is at the mouth of Bowman Cr. along the Lostine River (Figure 9C), and the population varies from 1-4 stems (Table 7). It occurs here with several other rare ferns, in one of the few sites separated from horse traffic by a grove of trees.

Ed Alverson and the writer discovered a second site for three plants of *Botrychium paradoxum* near French Forest Camp (Figure 10B). One plant was seen west of the Lostine River and two individuals were seen east of the river (see sketches in Appendix 3). These meadows are at risk under current Forest Service management. They should become part of a comprehensive basin management plan that places more value on the globally important botanical biodiversity.

A solitary individual of *Botrychium paradoxum* was discovered in Desolation Meadows by Keri Yanskey of the Forest Service in 1992 (Figure 12b). Although Wagner (1992) was

unsure of the identity of this plant, it was field verified in 1993 by Herb Wagner, Florence Wagner and the writer. This meadow system needs management to protect it from grazing, and to keep a large population of an undescribed *Botrychium* species intact, to facilitate taxonomic and other studies. Desolation Meadows also hosts significant populations of *Botrychium lanceolatum* and *B. pinnatum*. It should be set aside as a Botanical Interest Area, Special Interest Area, Area of Critical Environmental Concern, or other special designation recognizing its botanical importance.

Type Locality: Montana (Wagner and Wagner 1981)

Habitat

The Bowman site is at 5250 feet in elevation, on Quaternary surficial deposits adjacent to (limy?) sedimentary bedrock in the Triassic/Jurassic Hurwal Formation. The microsite is a S-facing bank on an alluvial fan, on dry soil, in sun for most of the day, but receiving partial shade in late afternoon from the steep canyon wall and from scattered *Pinus contorta* in the area. There are a series of small openings along the parallel alluvial fans here, and they support other rare *Botrychium* species , including one of the few U.S. stations for *B. pedunculosum*.

All Oregon sites are between 5000 and 5500 feet in elevation, with nearly full sun, gentle slopes, and open meadow plant associations in mesic soil.

Outside of Oregon paradox moonwort has been reported from deep shade under *Epilobium angustifolium*, or in sunny meadows.

Some of the associated species are listed in Table 8.

Threats

The small size of the populations makes them vulnerable. Grazing, trampling, camping, botanical collectors, photographers, and exotic weeds are potential threats.

Recommendations: Future inventories for the species are needed, and should be conducted in July. Because this species is a Federal C2 candidate for the endangered species list, and there are so few known Oregon localities and plants, all sites should be designated and posted as no camping/no grazing zones. In the Lostine valley, signs could be posted along

Lostine River Road stating that camping and grazing are allowed only in designated areas. The Bowman site is not in the Eagle Cap Wilderness, but is on Forest Service land. The Forest Service should start monitoring use patterns on trailheads like the Bowman Tr., to determine acceptable levels of use, and the impact of that use on other resources, such as rare plants.

Additional management recommendations are provided in the management section of this report.

Botrychium pedunculosum W. Wagner (stalked moonwort)

Range

This species is globally rare (Figure 14). In Canada it is recorded from British Columbia east to Saskatchewan, and there the populations are all small (Wagner and Wagner 1983, 1993, pers. comm.). The United States has only the type locality in the Wallowa Mts. (Figures 5, 9A), and three adjacent sites located during the surveys of 1991-1993 (Figures 9B, 9C, 10B; Table 9). There are recent reports of the species from Washington State (WNHP 1994).

All Oregon records are from Wallowa County, in the Eagle Cap Ranger District (Figure 5).

The type locality has a vigorous population of 272 plants (Table 9, Figure 9A). The plants are well dispersed along the shore of the river, and in scattered patches in the meadow and meadow-forest ecotone (See sketches in Appendix 4). The entire area should be a genetic preserve, to protect the significant populations of *Botrychium crenulatum, B. lanceolatum, B. pinnatum* and *Botrychium pedunculosum*. Currently cars can park on some of the rare plants, and the informal campground receives common use, because it is set off from the traffic on the road and is quite close to the river shore. Already significant habitat has been lost to the road and trampled camping area. Fencing to prevent pack animal grazing is desirable, and a major barricade (such as large rocks) is recommended on the access road. Educational signs should note this is an area closed to the public for revegetation, until remnants of the road are grown over with native grasses and forbs.

The French Camp colony (Figure 10B) is also significantly large, with 99 plants counted in 1992. Here *Botrychium pedunculosum* can be found both east and west of the river, and east and west of the road, in the large series of small meadows. This is another significant site for *Botrychium paradoxum* as well as hosting an undescribed species of *Botrychium*, and other rare species. Unfortunately the site is being steadily degraded by campsite trampling, parking and a pack animal facility. These should be closed and fenced off immediately to

allow the meadows to revegetate with native grasses and forbs. (The camping and horse facilities should be relocated elsewhere in the valley, preferably below the guard station, where there is no conflict with the rare plants in the meadows.) This site should receive special designation as a botanical interest area, special interest area, area of critical environmental concern, etc.

The Bowman Cr. station (Figure 9C, Appendix 4, Table 9) supports 8 plants. It was discovered in 1991, and is of interest for its significant populations of *Botrychium paradoxum* and an as yet unnamed *Botrychium* species, as well as a small population of *Botrychium ascendens*. It should be relatively easy to manage, since most of the site is not fronting on a road.

In a remarkable feat of memory, W. Herb Wagner led the writer and Ed Alverson to an additional site for *Botrychium pedunculosum* that he had discovered in 1983 (Figure 9B), where diligent searching finally yielded a solitary individual. This is the paratype population (Wagner & Wagner 1986). It grows with a number of individuals of an undescribed *Botrychium* species.

Type Locality: Wagner and Wagner (1986)

The type locality is given as "1.6 mi S of ranger cabin, 13.3 mi S of Lostine Church, grassy second-growth area along road, Lostine River Valley, Wallowa Co., Oregon." The holotype specimen (*Wagner 83361*) is deposited at MICH, the University of Michigan herbarium at Ann Arbor.

A paratype is also given in Wagner and Wagner (1986): "1.2 miles N of Bowman Trail, Lostine River Valley, Lostine River Valley, Wallowa Co., *Wagner 81330* (MICH)." This population, revisited in 1993, had only a single individual (Table 9, Figure 9).

Studying the map distances on Figures 9-10, it can be shown that the paratype and holotype refer to the same place, i.e., 1.2 miles N of the Bowman Trail is the same as 13.3 miles S of Lostine Church. This was confirmed repeatedly with an odometer during this survey. D. Wagner also pointed this out to the writer. W. Wagner and F. Wagner (1986) were in error when stating the holotype locality is 1.6 miles south of the ranger cabin. The guard station/ranger cabin is 1.3 miles from the type locality. This was confirmed by Ed Alverson, who visited the type locality with the writer and with W. and F. Wagner in 1983.
A large marsh with very few *Botrychium* is found at 1.6 miles S of the guard station. No habitat for (and no plants of) *B. pedunculosum* have ever been located 1.6 miles S of the ranger cabin. Forest Service and ONHP files should be corrected to reflect this. However, the paratype locality does exist, at 0.4 road miles south of the holotype locality, which is 1.7 miles S of the guard station. Small distances make a big difference with small plants.

The holotype locality consists of a series of small openings and old stream channels, several of which have colonies of *B. pedunculosum*, for a N-S stretch of at least 0.2 miles between the Lostine River and the Lostine River Road. A well-defined pullout (1.3 miles S of the guard station) and campground marks the southern extent of the population.

Habitat

The Lostine River populations of stalked moonwort are found between altitudes of 5000 and 5400 feet. Each is on Quaternary surficial deposits. Two of the sites are close to sedimentary rocks of the Hurwal Formation, which may be limy. Large parts of the east wall of the Lostine Canyon are composed of pure limestone in the Martin Bridge Formation, and it is possible that all of the sites are influenced by circumneutral or calcareous ground water percolating through limy bedrock or limy glacial till or morainal debris.

All sites are in open stands of *Pinus contorta*, among low herbaceous growth, most commonly strawberries, *Fragaria virginiana*. Each site receives some shade early and late in the day due to the steep canyon walls, but the plants are in relatively sunny positions in the small forest openings. Soil moisture varies, averaging mesic. French Camp site is mesic. A south-facing bank at Bowman is dry by mid-summer, and plants there do not last much beyond mid-August before wilting. In contrast low damp channels in abandoned oxbows at the type locality support dense grasses and there the *B. pedunculosum* persists well into September.

A list of associated species is found in Table 10.

Threats

All the populations of this species are threatened by camping, compaction, erosion, trampling, pack animal grazing, exotic weeds, firewood cutting, and campfire rings. At French Camp and the type locality Off Road Vehicle (ORV) use by hunters or firewood cutters is a potential threat. Present plans to manage the wild and scenic river corridor for Outstanding Resource Values (ORV) are inadequate for protecting the rare plans, and need strengthening.

Recommendations: All locations for *Botrychium pedunculosum* should be established as botanical preserves, and the areas should be designated no camping/no grazing zones. The access road at the type locality (Figure 9A) should be blocked with large rocks. This has

worked on other road closures in the valley. Signs at all areas should explain why grazing and camping are no longer allowed. An effective new policy would be to limit grazing, firewood cutting, camping, etc. in the Lostine Valley to designated sites. Choose the sites after a good botanical inventory, for the canyon floor supports a number of rare *Botrychium* and *Listera borealis* in the open areas favored for recreational use.

Botrychium pedunculosum needs more survey work. The majority of the west side of the Lostine River is unexplored, and may yield more sites. At present, the species should be monitored to determine if the populations are stable, increasing or decreasing. Recreational and firewood cutting use in the Lostine Valley should also be more closely monitored. The data suggest a change from C2 to C1 status is warranted if no new sites are located, and if the Forest Service fails to act to protect the known populations.

More management recommendations are provided in the management section of this report.

5. Management

The short-term management goal is to prevent the foreseeable extirpation of four rare C2 species of moonwort in Oregon: *Botrychium ascendens*, *Botrychium crenulatum*, *Botrychium paradoxum*, and *Botrychium pedunculosum*. If the Wallowa-Whitman National Forest and the Umatilla National Forest and the Klamath National Forest agree to follow the steps outlined below, it will help keep each of these species off the federal endangered species list. *Botrychium pedunculosum* and *Botrychium paradoxum* are the most at risk, because of the recreational conflicts in the Lostine Valley. Five year reviews of the population monitoring data will be necessary to redirect management and preservation efforts, to ensure attainment of the long-term management goal: that the four species maintain viable populations for the next century and beyond.

Management of moonwort species will require habitat management at some sites. In northeastern Oregon, the *Botrychium* spp. are often found in early successional open habitats. Management of these habitats, until recently, has been entirely for recreational use, grazing, and as staging or access areas for tree cutting. Fires in these areas were suppressed this century. Little or no intrinsic value was placed on the native flora of the natural meadows, although the meadows support an important segment of the biodiversity of the region. The meadows with the largest populations of rare *Botrychium* should be designated as genetic reserves and left undisturbed.

There are several factors to address in managing the *Botrychium* taxa:

1) Short and long term threats to known populations
2) Establishing undisturbed genetic reserves for each species
3) Manipulating habitats to create, restore, maintain, or enhance vegetation or plant populations
4) Monitoring of human and biological factors at important sites.

Flexibility will be key as scientists learn more about the biology and distribution of *Botrychium*. Management practices will need to be reviewed frequently by botanists, planners and recreation specialists, to incorporate the latest monitoring results and to cope with changing land use and new recreation trends. For example, the dramatic increase in off-road bicycle use in western Oregon has degraded many meadows and trails. Its inevitable impact on eastern Oregon's backcountry resources should be anticipated proactively instead of reactively.

Every five years the forest botanists for the Umatilla National Forest and Wallowa-Whitman National Forest should meet to discuss short-term population trends and management needs. Long-term needs for the rare *Botrychium* can not be met until there is more inventory across cordilleran western Canada and the northwestern United States. Perhaps in another 10-20 years, at the current rate of data collection, we will know enough about the rarest taxa to prepare multi-regional management plans that can ensure these species will remain a viable portion of our biodiversity in North America. The need for more data to fill in the big picture does NOT lessen the immediate need for Forest Service action in Oregon to protect known populations of *Botrychium ascendens*, *Botrychium crenulatum*, *Botrychium paradoxum*, and *Botrychium pedunculosum*.

The Wallowa-Whitman National Forest has requested that its *Botrychium* populations be classified in three categories. These are: (1)"Management Areas" where there would be no competing resource uses, (2) "Multiple Use" areas, where the ferns compete with consumptive resource use, and (3) "Unprotected" sites. The problem with this 3-parted classification is that over the long-term, with steady or accelerating human use and fragile plants in early successional habitats, categories 2 and 3 are not substantially different. Table 1 divides all known Botrychium populations into categories (1) and (2), where category (2) effectively includes category (3). The division of known sites is by population size. Category 1 populations meet the minimum population size listed in Table 1. These are equivalent to genetic preserves. All type localities and significant (large) populations are included. These can be determined by looking at the data tables of Zika (1992a), electronic database updates from ONHP, and Tables 3,5,7,9 in this report. Guidelines for managing these plants are provided in general below, and with specific recommendations in the following section. Plants in smaller populations are in category (2), although some of the general guidelines below are directed at them as well. Unprotected sites include all the small populations of common and rare species.

General guidelines

Several concerns need to be addressed for all populations of the federal candidate *Botrychium* (Table 2), which apply, in general, to most *Botrychium* species that are considered rare, threatened or endangered in northeastern Oregon (Table 1). Other rare plants (Tables 4,6,8,10) associated with the rare *Botrychium* will benefit as well.

● **Inventory** All activities that may affect known populations or potential habitat for populations should be preceded by 1-2 years of botanical inventory. This includes logging, firewood cutting, road/culvert improvement or maintenance, herbicide use, prescribed fire, livestock grazing, commercial pack animal grazing, opening of new campgrounds and new roads, maintenance/installation of utilities or utility corridors, etc. One year's search is often insufficient, given the sporadic appearance of individuals that has been documented by monitoring projects (e.g., Montgomery 1990, Lesica & Ahlenslager 1994, D. Wagner pers. comm., W. H. & F. Wagner pers. comm.). Only through continued inventory and *de novo* searches will we learn more about the biology, distribution and abundance of *Botrychium*.

Some recent Forest Service *Botrychium* inventories have resulted in poor documentation of what may be the rarest species. *Botrychium* surveys must be performed to current standards for collection and mapping of locality data, as well as special standards for preparation of carefully spread and pressed leaf specimens from at least 5-10 individuals of each taxon, to facilitate accurate identification. See discussion of collecting technique in Wagner (1992).

● **Data sharing** Annual summaries of known population sizes, population trends and relevant monitoring results should be shared electronically with all Forest Service ranger districts and BLM resource areas that have populations of the rare *Botrychium* species. Coordination of this could rotated between botanists on different forests, starting with the Umatilla and Wallowa-Whitman.

● **Genetic reserves** Establishment of reserves at type localities and in pristine habitats should become a priority. Competing and destructive resource and recreational use should be eliminated from these areas. Habitat management in other areas should be minimal, and considered experimental, until the effects of the management are compared with unmanaged populations in several undisturbed, genetic preserves over the course of 5-10 years. Monitoring of genetic preserves should provide baseline data for comparison with managed areas (see Biology section of this report). At least two permanent reserves should be established for each rare taxon on each forest, in addition to a reserve for the type locality, if present. The reserves should include the entire rare *Botrychium* population, its entire surrounding habitat, and a buffer (usually forested) around the habitat sufficient to insulate the habitat from adjacent land use practices such as grazing or logging. If the boundary of the preserve is forested, the perimeter should be a minimum of three hundred feet, or if

greater: three tall tree lengths from the outer edge of the non-forested habitat. The buffer may be smaller if there is a natural break in the topography, such as a lakeshore, ridge or talus slope.

● **Significant populations** All type localities for *Botrychium* should be considered significant. Minimum sizes for significant populations are provided in Table 1. In addition, in Oregon, any populations newly discovered that meet or exceed the guidelines in Table 1 should automatically be considered significant. Significant populations should be managed as category (1), without competing consumptive resource use, including recreational use.

● **Monitoring ferns** Every year pristine populations and type localities should be censused completely. With limited time and resources, consider establishing marked permanent plots to annually sample large populations or large habitats. Monitoring will provide important information on the natural annual variation in populations of the different species. Those species that are stable or increasing can be monitored less intensively than those showing declines over the next ten years. For populations declining more than 25% more intensive demographic monitoring should be instigated (refer to the discussion in the biology section of this report, and the numerous ODA reports for techniques and time estimates). At least 2-3 unmanaged, undisturbed populations of each rare species should be monitored on each forest (2-4 days/sp/yr). Monitoring for presence or absence of invasive competitive weeds in the vicinity should be performed annually as well (1 day/yr).

● **Land use history** One research priority should be documentation of the land use history in *Botrychium* habitats in historical times. Homesteading, fire frequency, pack animal use and livestock grazing should be quantified, to provide perspective. Original land survey records, historical photographs, aerial photo sequences, accounts of old-timers, archives in historical museums, old newspapers, tree cores, soil profiles, and AUM records will all provide clues. Significant *Botrychium* populations (genetic preserves, type localities) should be evaluated for natural and human disturbance history.

For example, were sheep herds of the 1800s overgrazing small discontinuous meadows at low elevations in the floodplain of Hurricane Creek and the Lostine River? Large sheep herds certainly passed through these meadows en route to the higher elevations each summer. Or was the historical overgrazing largely confined to subalpine and alpine meadows? The answer to this will color our perception of what constitutes "pristine" *Botrychium* habitat in the Eagle Cap Ranger District. It also raises the possibility that *Botrychium* populations are in the midst of a long-term slow recovery from severe grazing pressure at the turn of the century, and that there are no true "baselines" for data comparisons in the region.

● **Monitoring people** Visitors have an enormous impact or potential impact on the known *Botrychium* habitats. Recreation use must be quantified. Recreation planners will be needed as FS staff or contractors.

For example, annual figures on the number of commercial packing trips staging in the Lostine River and Hurricane Creek trailheads should be gathered. Counts of the numbers of pack animals, numbers of pack trains, numbers of day hikers, numbers of backcountry campers, numbers of roadside campers, numbers of cars, and use of parking/camping/firewood cutting areas are needed in the Lostine Valley to determine:

1) current level of use
2) pulses of use (in relation to the growing season)
3) the rate of increase of use
4) the demand for conflicting use of botanically sensitive areas
5) acceptable alternative staging areas with less impact on rare plants

Until these questions are answered it is not possible to accurately design a recreation plan for the area. Any recreation plan will need to work around the rare ferns that are being managed as category (1).

● **Fugitive status** Management must consider that most *Botrychium* species are found in openings in the Wallowa-Whitman National Forest. As such they are fugitives from shade and later stages of woody plant succession. The fern meadows have naturally attracted recreational use and exotic grazing animals, creating a conflict.

In the following section, no management recommendations are offered for *Botrychium pumicola*, a Cascade Mts. endemic, or for undescribed taxa. No management (category (3) is required for three common species: *Botrychium simplex, B. multifidum,* and *B. virginianum.* Many of the guidelines (above and below) can be applied to significant populations of other rare *Botrychium* species (i.e., *Botrychium campestre, B. lanceolatum, B. lineare, B. lunaria, B. minganense* populations in meadows, *B. montanum* populations east of the Cascade Mts., and *Botrychium pinnatum*) in category (2), but they are aimed at a smooth transition between the present situation (consumptive use, category (3)) and the desired condition of category (1) management.

Detailed recommendations

● **Lostine River valley** (Eagle Cap Ranger District, Wallowa-Whitman National Forest).

Most of the rare *Botrychium* sites are along the FS road above the Guard Station, with easy access. Conflicting demands for the meadows are threats to the ferns, and include camping, firewood cutting, parking, grazing and staging pack animals. Casual trampling by

hikers and fishermen is another concern. Despite recent listing as a wild and scenic river, and the nearness of the Eagle Cap Wilderness Area, passive management will not suffice to protect most *Botrychium* populations in this busy corridor. The Forest Service environmental assessment for managing the wild and scenic river corridor noted (WWNF 1993, III-14) there are no data for determining how visitor use will increase and how this will impact rare plants in the corridor. The Forest Service should address this shortcoming in their legal obligation. The following recommendations are made for the roaded area between Two Pan and the FS Guard Station (Figures 9,10). None of the recommendations should conflict with wild and scenic status:

Continue to inventory for more populations of rare *Botrychium* species, especially in openings on the west side of the river, and anywhere there appears to be a potential conflict with human use in the valley.

Do not widen or pave the Lostine River Road on Forest Service land. This will increase use, improve access, lead to greater demands on the small meadows, destroy some roadside rare plant sites, increase the spread of non-native weeds, and encourage calls for more campgrounds in the upper valley. Infrequent and minimal road grading is a cost effective and passive technique to minimize the acceleration of use in the valley.

Increase the Forest Service presence in the valley with volunteers, interns, coops, etc. The writer rarely saw any personnel from the guard station over the last three years of field work. A "guard" should live in the station instead of commuting there, during the camping and hunting seasons.

Reduce the number of available campgrounds and campsites in the upper roaded valley, above the guard station. Collecting modest fees for camping and parking might reduce use and pay for personnel (but increase resentment of government oversight). The recent environmental assessment for wild and scenic river status chose NOT to close the campgrounds within 75 feet of the river unless they affected fishery values (WWNF 1993). FS staff recommendations and the recommendation of this writer is that the botanical "ORV" (Outstanding Remarkable Value) should have priority over the use of the rare fern meadows for camping. All meadow campsites and all meadows between the road and the river should be closed to camping and to parking and to grazing. These sites are rare fern meadows, or potential habitat for the ferns.

If campground space is limiting, establish new campsites or campgrounds in the lower canyon, below the Guard Station, or on private land at the base of the canyon.

Restrict fires to established, designated locations in campgrounds. The proliferation of firerings threatens some *Botrychium* individuals in significant populations.

Discourage firewood cutting during the growing season. Promote, through signs and educational efforts, the use of self-sufficient stoves with bottled fuels. The present

management plan (WWNF 1993, III-14) allows firewood cutting even where it can have a direct negative impact on rare plants. The current management plan is inadequate for protecting candidates for the federal endangered species list.

Reduce and finally phase out all grazing in the meadows above the guard station. Pack animals should be provided with all feed, and should not be tethered or grazed in any of the rare *Botrychium* meadows, only in forested areas where there have been prior botanical inventories. If there is a need for additional facilities for commercial trips with pack animals, establish one in the canyon below the guard station, or on private land at the base of the canyon. Post signs explaining the policy at the base of the canyon and at all trailheads, campgrounds and staging areas. Current plans (WWNF 1993, III-14) are to allow stock animal grazing in designated areas at all trailheads, and some campgrounds. The current plans are inadequate for protecting the rare meadow species.

Educational programs, including signs and nightly visits to the campgrounds can explain the reduction in the number of available campgrounds and campsites and grazing areas in the upper roaded canyon. Emphasis can be placed on the need to protect the wild and scenic values of the river corridor rather than on the rare plants in the meadows. Advertising the rare plants could lead to overappreciation, and well-meaning visitors trampling small ferns while searching for them, or worse, digging them to transplant.

One option is to increase the licensing fees for commercial outfitters and their pack trips into the wilderness. The money, coming from the users, will pay to help explain and enforce the new grazing and camping regulations in the roaded portion of the valley.

Block vehicle access to all meadows with significant *Botrychium* populations. Large rocks across existing roads effectively discourage vehicles. Let these former roads revegetate naturally. DO NOT seed with exotic grasses (e.g., *Dactylis glomerata, Poa pratensis, Alopecurus pratensis*). If the roadbeds must be seeded, use hand collected native grass seeds from the valley. A district botanist should supervise the program to ensure native grasses are used. Post signs explaining the closed roads and campgrounds are revegetation zones, to discourage walk-on use.

Maintain cordial relations with the owners of the private inholding (Lapover Ranch) in the valley. There is a significant *Botrychium lineare* population (the type locality, Figure 10) on the private land west of the road. It should be monitored annually if possible (see Biology section of this report); in recent years the plants have suffered from trampling and grazing. This site should not be publicized, to respect the privacy of the owners. Public botanical field trips, fern photographers, etc. should not be directed to this site.

Establish well-defined and marked trails along the river to channel fishermen and casual hikers, and minimize random wandering across the rare fern meadows. ANY new trail construction should be preceded by botanical surveys for *Listera borealis, Botrychium*, etc.

Where invasion by *Pinus contorta* and other woody plants is reducing the size of meadow habitat, experiment with controlled burns to reduce woody plant cover and encourage graminoids and forbs. Do not burn an entire rare plant site, in case there are unintended negative side effects on the rare plant. Monitor all rare plants for two years before and two years after the burn year, so there are data to compare with populations in unmanaged genetic reserves. Evaluate the results of the burn before continuing the management program at other sites. Trees cut from these areas in winter, when there is at least two feet of snow cover and the ground is frozen, could be supplied as firewood to visitors staying in the campgrounds in the summer. Slash, trash and other debris must be removed from the meadow while there is snow cover and the ground is frozen. WWNF (1993, III-14) states the type locality for *Botrychium pedunculosum* will be enhanced, possibly with fencing and prescribed fire. It is suggested that the type locality be fenced first, and that fire is used on other sites, until monitoring shows an effective prescription and a positive response from the ferns.

Establish a contingency plan in the event of a wildfire in the valley. Containment plans should prevent the use of heavy machinery, tracked vehicles, fire retardants, chemicals, blasting lines and major soil disturbance in the significant fern meadows. If access to water is needed, use existing campground roads. If helicopter access is required, use existing parking areas. The meadows could be used as firebreaks by setting backfires, if necessary. The special fire-fighting restrictions in the fern meadows must be pre-planned and marked on FS documents and maps. All appropriate fire-fighting coordinators must be informed *a priori* of any fire, so ground crews are notified.

Monitor annually for the presence or absence of noxious weeds along the roadsides, in meadows where pack animals are allowed, and in all *Botrychium* meadows. If noxious weeds become established near any rare *Botrychium*, control them immediately, by hand pulling, without the use of herbicides.

Do not spray this valley to control cyclical forest pests and diseases. Poisoned lepidopterans or orthopterans may have adverse effects on rodents low in the food chain, and these animals may be important in the life history of the rare ferns.

Commercial sheep and cattle grazing should be prohibited from the valley on public lands. All significant *Botrychium* meadows should be withdrawn from mining and mineral extraction.

Do not consider building additional roads or dams or bridges in the Lostine River canyon. Do not usurp any meadows with additional parking areas. Any future parking needs should be met in forested areas, after botanical clearance surveys.

● **Hurricane Creek canyon** (Eagle Cap Ranger District, Wallow-Whitman National Forest). There are no private inholdings in this basin near the rare plant sites. The rare fern sites are all FS meadows along the Hurricane Creek Trail, within the Eagle Cap wilderness, more than a mile south of the trailhead and terminus of the road (Figures x,x). Even with wilderness designation, the *Botrychium* species face numerous threats from recreational users (e.g., campers, hunters, commercial pack trips, horse and lama grazing and trampling). Passive management as a wilderness area is insufficient to ensure the survival of the rare ferns over the coming decades. Most of the meadows are at risk. Hunters camp close to the trailhead, while backpackers and guided summer trips usually go higher in the drainage. Because the *Botrychium* are so patchy and concentrated, a single fire ring or trenched tentsite could eliminate a large percentage of some significant populations. Some needed steps are outlined below:

Continue to inventory for more populations of rare *Botrychium* species, especially in openings on the side of the river opposite the Hurricane Cr. Tr., and anywhere there appears to be a potential conflict with human use in the valley.

All grazing, camping and fire-building should be prohibited from the fern meadows, especially at Billy Jones Cr. meadows (north and south of the creek mouth) and the type locality for *Botrychium ascendens*. Important areas should be posted with the restrictions, even though this is a wilderness. Signs should be designed and placed appropriately, to avoid diminishing the wilderness experience of visitors.

Educational signs at the trailhead should explain where camping, grazing and fire restrictions are in effect.

All commercial guides for pack trips in this valley should be asked to help self-enforce the camping, grazing and fire restrictions. Their customers may be the most effective reporters. A slight increase in the fees for commercial licenses could help pay for an educational awareness program.

Before designating alternatives to meadow campsites along the trail, each area should be inventoried over two growing seasons by a botanist skilled at identification of *Botrychium* ferns. This will ensure that the alternative sites do not harbor rare moonworts, and that moonworts are not dormant the year of the first search. Alternative campsites should be forested to minimize the possibility of fern habitat.

All pack animals should be required to carry all necessary feed for the trip. To avoid the possibility of the introduction of noxious weeds, this should NOT be hay. Pack animals should not be tethered in *Botrychium* meadows, where they might graze or trample the rare ferns. Informational signs should be posted at the foot of the valley. Materials explaining this policy should be made available at the FS visitor center. Protecting the wilderness from noxious weeds can be emphasized over the occurrence of rare plants.

Do not spray this valley to control cyclical forest pests and diseases. Poisoned leptidopterans or orthopterans may have adverse effects on rodents low in the food chain, and these animals may be important in the life history of the rare ferns. The loss of some tree cover in the valley may open potential habitats for the rare ferns.

Commercial sheep and cattle grazing should be prohibited from the valley on public lands. All significant *Botrychium* meadows should be withdrawn from mining and mineral extraction.

Discourage firewood cutting during the growing season. Suggest campers bring self-sufficient gas stoves and fuel, to reduce fire danger. This will decrease the number of firerings in the rare fern meadows, which threaten some *Botrychium* individuals. Have volunteers or backcountry rangers scatter the remains of existing firerings in significant *Botrychium* sites.

Use only native, local seed sources for the revegetation of any denuded areas in the valley. Use neither non-native species nor seed sources from outside the county. Have a district botanist supervise any revegetation effort.

ANY new trail construction or major trail maintenance should be preceded by botanical surveys for *Listera borealis, Botrychium ascendens*, etc. When landslides or avalanches obscure the existing trail, try to relocate the trail on the most xeric portion of the new ground.

Where invasion by *Pinus contorta* and other woody plants is reducing the size of meadow habitat, experiment with controlled burns to reduce woody plant cover and encourage graminoids and forbs. Do not burn an entire rare plant site, in case there are unintended negative side effects on the rare plant. Monitor all rare plants for two years before and two years after the burn year, so there are data to compare with populations in unmanaged genetic reserves. Evaluate the results of the burn before continuing the management program at other sites.

Establish a contingency plan in the event of a wildfire in the valley. Containment plans should prevent the use of heavy machinery, tracked vehicles, fire retardants, chemicals, blasting lines and major soil disturbance in the significant fern meadows. The meadows could be used as firebreaks by setting backfires, if necessary. The special fire-fighting restrictions in the fern meadows must be pre-planned and marked on FS documents and maps. All appropriate fire-fighting coordinators must be informed *a priori* of any fire, so ground crews are notified when they are deployed.

Monitor annually for the presence or absence of noxious weeds in meadows where pack animals are allowed, and in all *Botrychium* meadows. If noxious weeds become established near any rare *Botrychium*, control them immediately, by hand pulling, without the use of herbicides.

Do not consider building dams or roads in the Hurricane Creek basin.

Do not establish predator control programs or poisoning programs in the basin; these may have adverse effects on the small mammal populations.

Do not publicize the recreational potential of the Hurricane Creek basin. Discourage such publicity from commercial guide services (there are many alternative non-limestone basins and lakes) and media reporters.

Curtail any exotic fish stocking programs that would encourage increased overnight use along Hurricane Creek.

● **Desolation Meadows** (North Fork John Day Ranger District, Umatilla National Forest). This is a long series of meadows along Desolation Creek. The rare *Botrychium* populations are in natural grasslands, with the solitary exception of a reported *Botrychium crenulatum* individual in a forest of *Pinus contorta* and *Pseudotsuga* (Figure 12a).

This area and the similar meadow system on Kelsay Creek (a tributary to Desolation Creek) should be inventoried for more *Botrychium* populations. Both are in the Indian Cr. allotment, a large allotment and one where there is ample upland forage for the ca. 4900 AUMs currently allotted (Allard pers. comm.). Rare fern populations in the meadows along the creek bottoms can be protected without affecting the overall grazing allotment. Large buffers of suitable habitat can be excluded from livestock with electric fencing, as shown by the fencelines established in 1993.

A genetic reserve should be established around the *Botrychium paradoxum* population and its *Botrychium* neighbors, including the undescribed taxon. A similar reserve should be established around the *Botrychium crenulatum* population.

Monitoring of population numbers should take place annually. Small populations should be completely censused. Large populations should be subsampled with a permanent plot, and the entire subpopulation in the transect or plot should be counted annually. These should be done in areas with domestic grazing and management fires excluded completely, as a control.

Experimental management burns should begin in pre-designated meadow areas adjacent to known fern sites. Prior botanical searches should have determined the targeted burn area did not have rare ferns. A close proximity maximizes the opportunities for fern dispersal and recruitment, and ensures the burn prescription will be useful if applied in areas with rare ferns.

After an effective burn prescription is found, it may be possible to experimentally burn a portion of the rare fern habitat to control woody plant invasion. Burning when the fern is dormant and the ground is wet or frozen would minimize the possibility of damaging the ferns or their soil fungi. Desirable burn objectives would include:

Creating, restoring and maintaining early successional fern habitat
Reducing thatch
Baring soil to provide gametophyte colonization sites
Killing encroaching woody plants
Reintroducing a natural environmental factor, fire
Reducing/eliminating the unnatural livestock grazing
Improving forage for native grazers such as elk
Fuel reduction on forested borders

Where subsequent inventories find rare *Botrychium* individuals in grazed areas and in burned areas there should be annual censuses. These monitoring results should be summarized at five and ten years for comparison. Five and ten year summaries should contrast grazing and burning management effects with the control populations in undisturbed genetic reserve areas, and long-term management should be based on the ten year results.

A shorter study will be unable to separate management from natural yearly population fluctuations caused by environmental factors.

Discourage or prohibit overnight camping and fire-building in the meadows near the rare ferns. Prevent overnight camping and fire-building at the rare *Botrychium* sites.

Block vehicle access to all meadows with significant *Botrychium* populations.

If needed, establish well-defined and marked trails along the creek to channel fishermen and casual hikers, and minimize random wandering across the rare fern meadows. ANY new trail construction should be preceded by botanical surveys for *Botrychium.*

Establish a contingency plan in the event of a wildfire in the valley. Containment plans should prevent the use of heavy machinery, tracked vehicles, fire retardants, chemicals, blasting lines and major soil disturbance in the significant fern meadows. If access to water is needed, use existing creek crossings on Route 10. If helicopter access is required, use the existing road. The meadows could be used as firebreaks by setting backfires, if necessary. The special fire-fighting restrictions in the fern meadows must be pre-planned and marked on FS documents and maps. All appropriate fire-fighting coordinators must be informed *a priori* of any fire, so ground crews are notified when deployed.

Monitor annually for the presence or absence of noxious weeds along the roadsides, in meadows where domestic grazing animals are allowed, and in all *Botrychium* meadows. If noxious weeds become established near any rare *Botrychium*, control them immediately, by hand pulling, without the use of herbicides.

Do not spray this valley to control cyclical forest pests and diseases. Poisoned leptidopterans or orthopterans may have adverse effects on rodents low in the food chain, and these animals may be important in the life history of the rare ferns.

Commercial sheep and cattle grazing allotments should be reduced in the valley on public lands. All significant *Botrychium* sites should be withdrawn from mining and mineral extraction.

Do not consider building additional roads or dams or bridges that would affect the rare fern sites. Do not usurp any meadows with additional staging areas for logging.

Any proposed logging activities in the drainage should be designed to minimize erosion and siltation in the creekside meadows. Large intact buffers should remain around all headwater drainages and creeks. Any proposed logging should be preceded by more inventories for *Botrychium crenulatum*.

● **Mt. Ashland** (Klamath National Forest). A small population of *Botrychium crenulatum* was verified on the southwest slope of Mt. Ashland (Appendix 2). It should be protected, and additional inventory should seek more plants at this site and in others along the ridgeline. Commercial livestock grazing should be eliminated from the site. Annual monitoring of the plants should commence. Annual monitoring should note the presence or absence of noxious weeds along the roadsides. If noxious weeds are found they should be hand pulled immediately. Habitat management to maintain the sub-alpine clearing is not necessary. Road maintenance schedules and practices should be scrutinized by the district botanist, and altered if needed to protect individuals of *Botrychium crenulatum* on the road margin.

6. Acknowledgements

I thank the many botanists and staffers who took the time to discuss taxonomic and management concerns, including Kathy Ahlenslager, Cathy Allard, Ed Alverson, Paula Brooks, Dana Field, Bonnie Heidel, Charles G. Johnson, Jr., Frank Lang, Larry Loftis, Laura Potash, Steve Rust, Karl Urban, Jim Vanderhorst, David Wagner, Florence Wagner, Herb Wagner and Keri Yanskey. In addition, I am most grateful to those who got down on their hands and knees and helped with the field work: Ed Alverson, Jerry Jenkins, Keli Kuykendal, Frank Lang (and his taxonomy class), Nick Otting, Martin & Daffodil Stein, Florence Wagner, W. Herb Wagner, Barbara Wilson, the Carex Working Group and the small army that Karl Urban and Keri Yanskey mobilized in Desolation Meadows. Funding for field work before 1993 provided most of the site data used in this report, and is

gratefully acknowledged. Those funds came from the Native Plant Society of Oregon, the Mt. Hood National Forest, and the Wallowa-Whitman National Forest.

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